# Grain Morphology

# Roundness, Surface Features, and Sphericity of Grains

In today's lab exercise we will examine some of the larger grains found in sediments and sedimentary rocks. We start out here because later we will apply some of the same ideas to much smaller, or microscopic grains. In particular we will look at the degree of abrasion or roundness of a grain, certain surficial markings that resulted from sedimentation processes, and the general shape of grains. Your objective here is to learn certain basic descriptive procedures for these grains and to explore just what one might be able to interpret from them. Through out this laboratory exercise and all subsequent ones keep in mind that it is very important to separate ***interpretation*** from ***description***. **Always observe, then describe, and finally then and only then interpret.** Work swiftly for there is a lot to do here and a lot to discover!

## Roundness

***Roundness*** "The degree of abrasion of a clastic particle as shown by the sharpness of its edges and corners, expressed by Wadell (1932) as the ratio of the average radius of curvature of the several edges or corners of the particle to the radius of curvature of the maximum inscribed sphere (or to one-half the nominal diameter of the particle.)" Bates and Jackson p. 546.

For descriptive purposes we can take the entire spectrum of roundness and break it up in to a small number of divisions each referred to as a ***Roundness Class*** ["An arbitrarily defined range of roundness values for the classification of sedimentary particles." Bates and Jackson, p. 547]. Below are verbal descriptions of the usual roundness classes as commonly applied.

***Well-rounded***: original faces, edges, and corners have been destroyed by abrasion and whose entire surface consists of broad curves without any flat areas. Roundness value between 0.60 and 1.00. (See Pettijohn, 1957, p. 59 for further details if you are so inclined)

***Rounded***: Round or curving in shape; original edges and corners have been smoothed of to rather broad curves and whose original faces are almost completely removed by abrasion. Some flat areas may remain. Roundness value between 0.40 and 0.60.

***Subrounded***: Partially rounded, showing considerable but not complete abrasion, original form still evident but the edges and corners are rounded to smooth curves. Reduced area of original faces. Roundness value between 0.25 and 0.40.

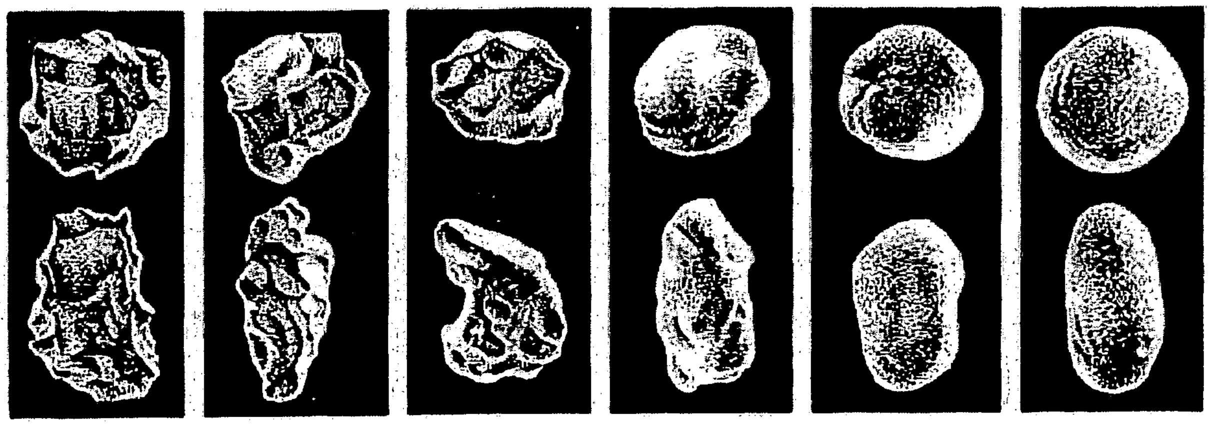
***Subangular***: Somewhat angular, free from sharp edges but not smoothly rounded, showing signs of slight abrasion but retaining original form. Faces untouched while edges and corners are rounded off to some extent. Roundness value between 0.15 and 0.25.

***Angular***: Sharp edges and corners, little or no evidence of abrasion. Roundness value between 0.0 and 0.15.

***Very Angular***: Powers (1953) used this as a class similar to that of Angular of Pettijohn (1957) and with a roundness value of 0.10 to 0.17. I would suggest to reserve this term for those few particles whose edges and corners are so sharp that they could cut you.

***Subangual-subrounded***: A term sometimes used when one can not decide which to choose as is generally the case when you are working with granular or smaller sized particles.

Some text and reference books use cartoon illustrations of these various classes (see below) and some geologists will actually carry a reference card with them with these same illustrations. This, I think, is a little silly. Similarly it is a bit silly to spend the day measureing circles and what not to get a numerical value for roundness. **It is best to train your eye to recognize the various roundness classes.**




Modified after Powers, M . C., 1953, Journal of Sedimentary Petrology, v. 23, p. 118.

**Exercise #1:** Take a good long look at the reference samples for roundness. Compare the sample to the above verbal descriptions of roundness class. Make sure you understand what each class represents and how to identify it.

**Exercise #2:** Examine each of the eight roundness samples and determine their roundness class. Do not compare them to the reference samples, do not even have the reference samples near by to tempt you. **Remember: in real life you will have to do this without carrying around a box of reference rocks. Record your answers in the first table in the EXCEL file grainmorph.xls and in your notebook.**

The tempting interpretation of roundness is that the greater degree of rounding the "older" or longer amount of time a grain has been involved in the weathering process. This is not exactly true for it assumes that the weathering environment and the abrasion process act hand-in-hand, they do not; it assumes that the abrasion rate is constant, it isn't; and it assumes that all stones resists abrasion to the same degree, they don't. At most all that one can infer from the roundness of a single stone is that the more rounded it is the greater the amount of abrasion is has been subjected to relative to other stones of a similar lithologic character (mineralogy, texture). The roundness of a single stone will tell you nothing, but the roundness character of a population of stones can provide some reasonably valuable data from which one could make a ***valid*** interpretation though not always a ***correct*** interpretation.

*Let me clarify something at this point; a **correct interpretation** is one where if you were to make a time machine and go back and witness the deposition event then you could correctly identify the process. A*

***valid interpretation**, on the other hand, is one based on evaluation of all the possible data available and logically analyzed by the interpreter; it may not be correct.* ***In this class I am only interested in valid interpretations.***

If you examine a population (two or hopefully many more) of stones then you will "time-average" the abrasion process that set them into various roundness classes and thus allow for an interpretation of the environment that the stones were subjected to. **Alluvial** or streambed gravel progress from an angular condition at their source area to greater degrees of rounding down stream. A population of rounded grains should be at some distance from their source, but you can not quantify that distance in terms of miles or kilometers. Similarly, **diluvial** gravel (those involved in glacial processes) are angular at their source site where the flowing ice plucked them up and become progressively more rounded down stream. **Beach** gravel tend as a population to become more rounded the longer they linger on the wave swept beach. A beach gravel deposit consisting almost entirely of well rounded stones would have the valid interpretation of having been actively involved in the beach process for a lengthy period of time, but you can not quantify the time in terms of years. A shore with big waves all the time does the job swiftly whereas a beach with dinky waves is no fun to surf and also take a great deal of years to do anything to a stone. Also soft stones on a big wave beach get turned to dust in a matter of seasons while durable stones may take millennia to acquire the same roundness class. Have you observed any of these? Have you observed other relationships of roundness? Learn to draw upon your own life experiences to aid in your interpretations. ***The more you see in this world the more correct your valid interpretations will become.***

## Surface Features

The process of rounding results in damage to the surface of a grain. Most of the time all you get is general wear and tear giving a dull surface. However, there are some surface features that you should be familiar with.

***Percussion Mark***: "A concentric scar produced on a hard, dense pebble (esp. one of chert or quartzite) by a sharp blow, as by the violent impact of one pebble on another; it may be indicative of high velocity flow." Bates and Jackson, p. 465.

***Striation***: "One of multiple scratches or minute lines, generally parallel, inscribed on a rock surface by a geologic agent, i.e. glaciers (glacial striation)" Bates and Jackson, p. 617.

***Impression Mark***: A depression into a grain, generally associated with fracturing where the grain has been mechanically damaged by adjacent grains being pushed against it. Frequently found in gravel beds caught up in a tight fold.

***Frosting***: "A lusterless ground-glass or mat surface on rounded mineral grains, esp. of quartz. It may result from innumerable impacts of other grains during wind action, or from deposition of many microscopic crystals" Bates and Jackson p. 248.

***Polish***: "A attribute of surface texture of a rock or particle, characterized by high luster and strong reflected light, produced by various agents; e.g. desert polish, glacial polish, of the coating formed on a gastrolith. Syn. Gloss" Bates and Jackson, p. 488.

***Differential Weathering***: "Weathering that occurs at different rates, as a result of variations in composition and resistance of a rock or differences in intensity of weathering, and usually resulting in an uneven surface where more resistant material stands higher or protrudes above softer or less resistant

parts." Bates and Jackson, p. 174

The above are to be taken as descriptive terms without implication as to how the feature formed. Most of the features have multiple methods of formation so therefore you can not say that such and such feature proves that it was deposited in a river, or was transported by a glacier, or was subjected to the action of wind. You can say that they suggest such an agent of weathering and that suggestion together with other lines of evidence may prove that there was a river there or that the wind blew or the mountains were glaciated. First rule you should learn in this class: ***Keep description separate from interpretation.***

**Exercise #3:** Look at each of the surface feature samples provided in the lab. Their background data is summarized in this FILE; print out a copy of this file and bring it to lab. Make sure you are familiar with each so if it should ever pop up again you could identify it.

# Sphericity ($\Psi$)

**Sphericity** ($\Psi$) "The relation to each other of the various diameters (length, width, thickness) of a particle; specifically the degree to which the shape of a sedimentary particle approaches that of a sphere" (Bates and Jackson, 1980). Sphericity could be thought of as the degree of equality of the three axes of a grain where in a perfect sphere the length, width and thickness (Long, Intermediate and Short) are all equal.

The following terms may be used in the field as descriptive names made without any serious measurements.

**Bladed**: L>I>S Think of a knife blade.

**Roller**: L>(I=S) Think of a rolling pin.

**Discoidal**: (L=I)>S Think of a CD.

**Spherical**: L=I=S Think of a ball, but a cube is also spherical!!!

**Quantitatively sphericity** may be expressed as the **Wadell Sphericity**:

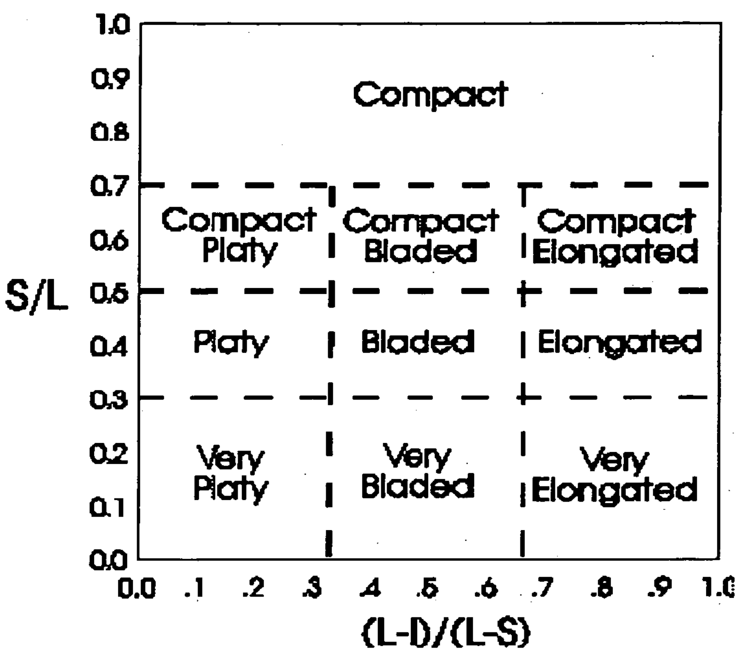
$\Psi_W = \sqrt[3]{\frac{V_p}{V_{cs}}}$ where $\mathbf{V_p}$ is the volume of a particle determined by immersion of the grain in a fluid and $\mathbf{V_{cs}}$ is the volume of a circumscribing sphere which may be taken as the volume of a sphere with a diameter equal to the long axis of the particle. To find the volume of the grain find a graduated cylinder large enough for the grain to slide down into. Fill the cylinder partially with water or other fluid and record the height $\mathbf{V_1}$ of that fluid. Then slide the grain gently down the inside of the cylinder and observe the new height $\mathbf{V_2}$. Subtract the initial height from the second and you have the volume $\mathbf{V_p}$ of the grain. The length of the long axis, **L**, can be had by using a micrometer for granules, vernier caliper for pebbles, a ruler for cobbles, and a meter stick for larger grains.

Sphericity may also be approximated by: $\Psi_A = \sqrt[3]{\frac{LIS}{L^3}}$ where **L**, **I**, and **S** are the long, intermediate and

short axes of the grain.

If one is trying to relate shape to settling rate then a Maximum Projection Sphericity: $\Psi_P = \sqrt[3]{\frac{S^2}{LI}}$ would work better.

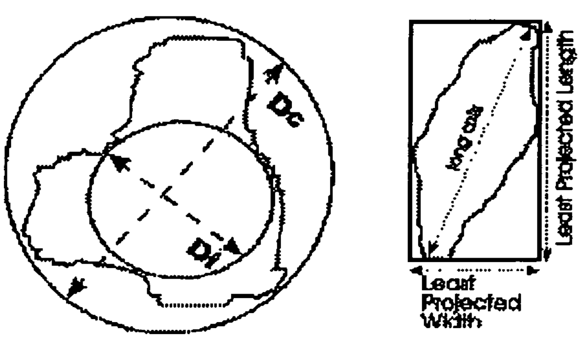
Some descriptive terms for sphericity that involve serious measurements:




**Examples: very elongated, compact, very platy**

For thin section work (two-dimensional) the **Riley Sphericity** has been used where:

$\Psi_R = \sqrt[2]{\frac{D_i}{D_c}}$ where $\mathbf{D_i}$ is the diameter of the largest inscribed circle and $\mathbf{D_c}$ is the diameter of the smallest circumscribing circle. See diagram below.




This would probably be best done with a photomicrograph of the grain or while observing the grain under a projecting microscope. A similar measurement called the Least Projection Elongation would be

easier to make. This is simply the ratio of the least projected width to the least projected length. See diagram above. Using this ratio then you can apply a name according to Folk (1974):

Under 0.60 very elongate

0.60 to 0.63 elongate

0.63 to 0.66 subelonate

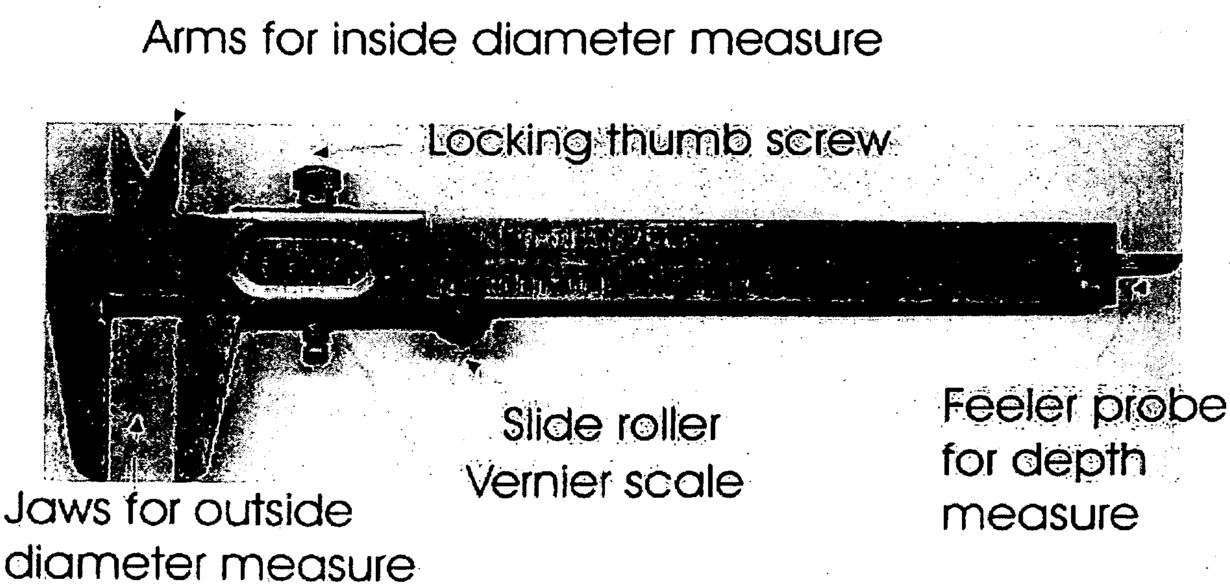
0.66 to 0.69 intermediate shape

0.69 to 0.72 subequant

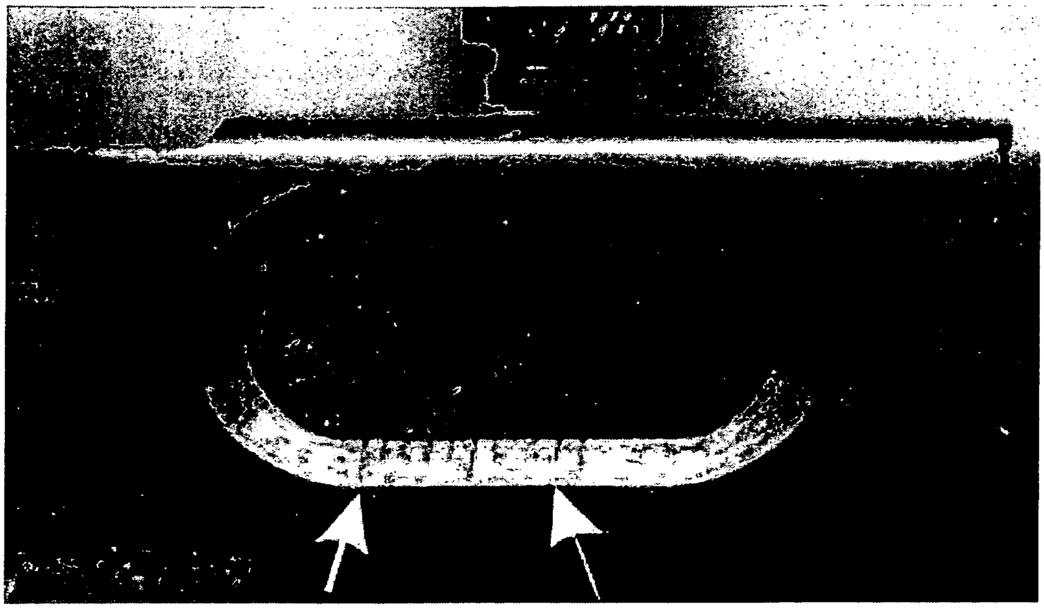
0.72 to 0.75 equant

Over 0.75 very equant

**Exercise #4:** Determine the various sphericities, $\Psi_W = \sqrt[3]{\frac{V_p}{V_{cs}}}$ $\Psi_A = \sqrt[3]{\frac{LIS}{L^3}}$ $\Psi_P = \sqrt[3]{\frac{S^2}{LI}}$ for each of the stones labeled A through J. To make the measurements of the lengths of the axes use a vernier caliper. Just figure the lengths to the nearest 0.1cm. The vernier calipers can be read much more accurately than that but is it really necessary? Watch your digits!!!!! Try not to spill to much water with the graduated cylinders and dry each sample when you have removed it from the cylinder. Record your data in the appropriate table in the EXCEL file grainmorph.xls and in your lab note book.




**Vernier Caliper**. To make a measurement unlock the locking thumb screw on the top with a slight rotation clockwise, open the 'jaws' slightly wider than the object, place the object to be measured within the 'jaws' and slowly use the slide roller on the bottom to slide the jaws loosely but snug against the object. Loosely lock the instrument then read the measurement using the centimeter scale (bottom scale on most calipers), see detail below.



A B

Close up of the vernier scale on the vernier caliper. This one current reads 1.19 cm (on bottom scale). The '1' and '2' and '3' refer to one, two, and three centimeters respectively. The divisions between are in tenths of a centimeter. On the outside oval area at the bottom there are an additional 10 marks. The left hand most mark (A) is to the right of the '1' hence 1 centimeter and just shy of or to the left of the second tenth mark, hence 1.1 centimeter. The 9th mark of the oval set (B) is directly opposite a mark on the main scale, hence 1.19 cm. (actually position now opposite the mark of the 2 cm position). All you need to do in this lab is read to the nearest tenth of a centimeter hence you should read this instrument now as 1.2 cm.

## References Cited

Bates, R. L. and Jackson, J. A., 1980. Glossary of Geology, 2nd Edition. Falls Church, Virginia, American Geological Institute, 751 p.

Folk, R. L., 1974. Petrology of Sedimentary Rocks. Austin, Texas, Hemphill Publishing Co., 182 p.

Pettijohn, F. J., 1957 Sedimentary Rocks 2nd ed. New York, Harper, 718 p.

Powers, M. C., 1953 A new roundness scale for sedimentary particles. Journal of Sedimentary Petrology, v. 23, p. 117-119.

**Lab Report to be completed before next week's lab.** Once you have recorded the data from the above exercises in the EXCEL file **grainmorph.xls** then use the spreadsheet computational powers of EXCEL to do the math for you. I will be looking at your use of these computational powers and expecting you to use engineering format, maintaining significant digits and designating the units. This last item you will have to do in the column head the other two you can set EXCEL to do for you and I will be looking to see that you did such. When you save your work to your disk make sure you name the file by the protocol listed in the course syllabus. It should be in this case like ABCDE02 where the

ABCDE are the first five letters of your last name; the 02 tells me that this is the second item that you have emailed to me. If your last name is shorter than 5 letters then just use whatever you have, I will figure it out. When you are finished email this EXCEL file to me as an attachment. Remember the subject line of the email must be GLY 312 and nothing else.

**Return to the Table of Contents**